WRITTEN REPLY

To Mr. Masaaki Moriuchi, Examiner at the Patent Office

1. Display of International Application
   PCT/JP03/13167

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5. Content of Reply

(1) Regarding the present application, we have received the PCT opinion as provided in accordance with Article 13 (PCT regulation 66) relating to, for example, international applications based on the Patent Cooperation Treaty, and we reply as follows.

(2) Regarding the invention of the present application

(a) The invention according to claim 1 of the present application comprises the following configurations A to D.

A: At least three lens groups,

B: that are arranged in order of a first lens group that has positive refractive power, and a second lens group that has negative refractive

power, as seen from the side having the longer conjugate distance,

C: wherein the first lens of the lenses of the second lens group as seen from the side having the longer conjugate distance has positive refractive power, and

D: wherein the arrangement of the refractive power of the lenses of the second lens group is one of positive, negative, negative, positive, negative and positive, negative, negative, negative, positive, negative, as seen from the side having the longer conjugate distance, and wherein the zoom lens does not have a joined surface.

(b) The invention of the present application is an invention in which in a zoom lens comprising at least three groups (configuration A), the arrangement of the lenses in the second lens group has been refined (configurations B to D). First of all, the second lens group has negative refractive power (configuration B). It is possible to ensure the negative refractive power of the second lens group by configuring the second lens group with a lens having negative power.

However, it is not possible to make the aberrations small just with a lens that has negative power. Accordingly, aberrations are corrected by attaching a lens having positive power.

In the application of the present invention, the interval between the first lens and the second lens of the second lens group is of particular importance. The first lens is a lens that has positive power, and the second lens is a lens that has negative power (configuration D). The first lens is attached principally for correcting distortion aberration, and it generates large, positive higher order distortion aberration. The first lens imparts a large angle of incidence on the posterior surface of the first lens with respect to a principal ray that has a large image height.

In this case, if the second lens is provided with a shape such that it does not impart a very large angle of incidence to a principal ray that has a tall height, then with respect to a principal ray that has a low height, the principal light ray is not bent particularly significantly by incidence on to and exit from the first lens, and it is possible to generate significant higher order distortion when in such a state.

A preexisting example that utilizes this higher order distortion aberration can be seen in the configuration of the first lens and second lens of a reverse telephoto-type (retro focus-type) wide angle lens, and

that of the first lens and second lens of the first lens group of the two-group zoom of the wide angle (page 22, lines 11 to 20 of the present specification[1]).

Here, if the first lens of the second lens group having positive power, and the second lens of the second lens group are joined, then the first lens imparts a large incident angle on the posterior surface of the first lens, and it is not possible to form the shape of the second lens such that a large incident angle is not produced with respect to a principal ray that has a large image height. In this case, the angle of incidence on the posterior surface of the first lens and the anterior surface of the second lens are the same, and it is not possible to generate higher order distortion aberration.

Consequently, even if the first lens is constituted by a positive lens and the second lens is constituted by a negative lens, if the first lens and the second lens are joined, then it is difficult to correct distortions as an entire lens system.

Furthermore, if the lens of the invention of the present application is used as a projecting lens for a projector, it is necessary that the lens is stable with respect to high intensity light beams from a light source. In the case of a high brightness projector, a 2 to 4 kW xenon lamp is used for the light source. If this lamp is used, then adhesives on the joined surface of the projecting lens will be turned yellow by the energy of the light beam that passes through, and this may cause delamination or cracking of the lens at the joined surface. Consequently, if using such a projector, then it is preferable to use a lens that does not have a joined surface.

(c) The comparison between a configuration that does not provide a joined surface (Working Example 1 of the present application) and a configuration that provides a joined surface (Comparative Example 1) is described below with reference to experimental results.

FIG. 1 and FIG. 2 of the present application show a lens configuration in which the first lens and the second lens of the second lens group are not joined. Table 1 and Table 2 of the present application

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[1] Translators note: Corresponds to Page 23 line 4 to 19 in the English translation.

contain the numerical data and zoom data of Working Example 1 according to the configuration shown in FIG. 1 and FIG. 2 of the present application. FIG. 3 and FIG. 4 of the present application show the aberration properties of Working Example 1.

On the other hand, FIG. 1A and FIG. 2A, which are attached, show a lens configuration according to Comparative Example 1 in which the first lens and the second lens of the second lens group are joined. FIG. 1A shows the configuration of the wide angle end of Comparative Example 1, and FIG. 2A shows the configuration of the telephoto end of Comparative Example 1. These correspond to FIG. 1 and FIG. 2 of the present application.

The attached Table 1A is the numerical data of Comparative Example 1, and FIG. 2A is the zoom data. These correspond to Tables 1 and 2 of the present application.

Comparative Example 1 is a design example having $F_{NO} = 2.5$ at the wide angle end, focal length $f = 37.05$ and a half angle of view of 24.25°. Parts r5, 6 and 7 of Table 1A constitute the joined lens, and r6 is the radius of curvature of the joined surface.

Moreover, the attached FIG. 3A and FIG. 4A show the aberration performance of Comparative Example 1. FIG. 3A shows the spherical aberration (mm), astigmatic aberration (mm) and distortion aberration (%) at the wide angle end of Comparative Example 1. FIG. 4A shows the spherical aberration (mm), astigmatic aberration (mm) and distortion aberration (%) at the telephoto end of Comparative Example 1. These correspond to FIG. 3 and FIG. 4 of the present application.

Excluding the presence or absence of the join between the first lens and second lens of the second lens group, the lens configuration of Comparative Example 1 and Working Example 1 are the same.

However, as may be seen by comparing the distortion aberration in FIG. 3A of Comparative Example 1 and the distortion aberration in FIG. 3 of Working Example 1, in Comparative Example 1 it is not possible to suppress the distortion aberration to as small a value as in Working Example 1 of the present application.

Consequently, even if the second lens group of configuration D of the present application provides a configuration in which the refractive power is arranged as positive, negative, negative, positive, negative, as in Comparative Example 1, when a joined surface is provided in the second

lens group, it is difficult to correct distortions as a complete lens system.

That is to say, as in configuration D of the present application, it is possible to demonstrate an advantageous result, which is a favorable correction of distortions, by constituting the second lens group such that it does not contain a joined surface.

(3) Difference to the cited inventions

The arrangement of refractive power of a second lens group such as configuration D of the present application is not described in Patent Documents 1 to 3.

The configuration of Patent Document 4 and 5 is similar in the arrangement of the refractive power of the second lens group, however, the second lens group is configured with a joined surface. In Patent Documents 4 and 5, there is no description of the technical idea of providing a non-joined surface in the second lens group in order to favorably correct distortion. Thus, we believe that it is not a simple matter to reach a configuration in which a joined surface is not provided based on the description in Patent Documents 4 and 5.

Consequently, configuration D of the present application is not described in Patent References 1 to 5, and in the case of the arrangement of refractive power as in configuration D, there is no description of the technical idea of providing no joined surface in the second lens group in order to favorably correct distortion. In other words, we are confident that the invention according to claim 1 of the present application and claim 19 to 21 that depend on this claim is not one that could be easily invented based on the descriptions of References 1 to 5.

6. Index of items provided

(1) Table 1A (numerical example of the lens configuration according to Comparative Example 1)

(2) Table 2A (zoom data according to Comparative Example 1)

(3) FIG. 1A (view of the configuration of the wide angle end according to Comparative Example 1)

(4) FIG. 2A (view of the configuration of the telephoto end according to Comparative Example 1)

(5) FIG. 3A (aberration performance charts of the wide angle end according to Comparative Example 1)

(6) FIG. 4A (aberration performance charts of the telephoto end according to Comparative Example 1).

(Table 1A)

r 1= 112.703	d 1= 3.4	n 1= 1.78472	v 1= 25.72
r 2= 74.567	d 2= 0.8		
r 3= 80.316	d 3= 11.3	n 2= 1.62299	v 2= 58.12
r 4=-7460.812	d 4=Variable		
r 5= 103.794	d 5= 4.8	n 3= 1.77250	v 3= 49.62
r 6=-1102.740	d 6= 2.5	n 4= 1.49700	v 4= 81.61
r 7= 25.857	d 7= 10.8		
r 8= -229.151	d 8= 2.1	n 5= 1.49700	v 5= 81.61
r 9= 44.830	d 9= 1.6		
r10= 36.137	d10= 6.2	n 6= 1.74950	v 6= 35.04
r11= 71.118	d11= 5.8		
r12= -43.032	d12= 2.0	n 7= 1.80420	v 7= 46.50
r13= -61.558	d13= Variable		
r14= 225.863	d14= 2.0	n 8= 1.88300	v 8= 40.80
r15= 59.999	d15= 14.7		
r16= 165.723	d16= 4.0	n 9= 1.59270	v 9= 35.45
r17= -109.614	d17= 0.0		
r18= 0.000	d18= 33.7		
r19= 176.639	d19= 7.5	n10= 1.49700	v10= 81.61
r20= -99.001	d20= 0.6		
r21= 44.048	d21= 8.9	n11= 1.49700	v11= 81.61
r22= 157.594	d22= 0.4		
r23= 183.815	d23= 2.6	n12= 1.80420	v12= 46.50
r24= 51.391	d24= 14.2		
r25= 225.920	d25= 4.7	n13= 1.77250	v13= 49.62
r26= 57.387	d26= 1.9		
r27= 90.553	d27= 12.0	n14= 1.45650	v14= 90.27
r28= -50.035	d28= 2.5		
r29= -44.100	d29= 3.5	n15= 1.83400	v15= 37.34
r30= -61.687	d30= 0.3		
r31= 77.992	d31= 12.2	n16= 1.45650	v16= 90.27
r32= -79.660	d32= Variable		
r33= 0.000	d33= 88.0	n17= 1.51680	v17= 64.20

(Table 2 A)

	wide angle end	telephoto end
d 4	1.96	25.968
d 1 3	31.618	1.998
d 3 2	19.375	25.156

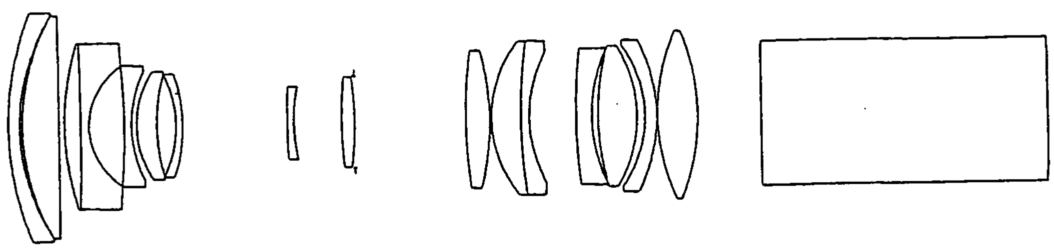


FIG. 1A

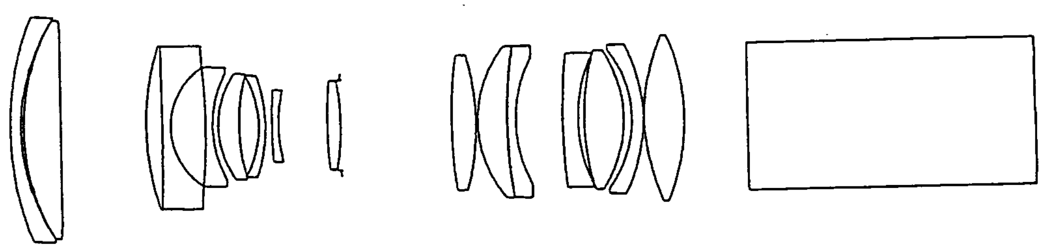
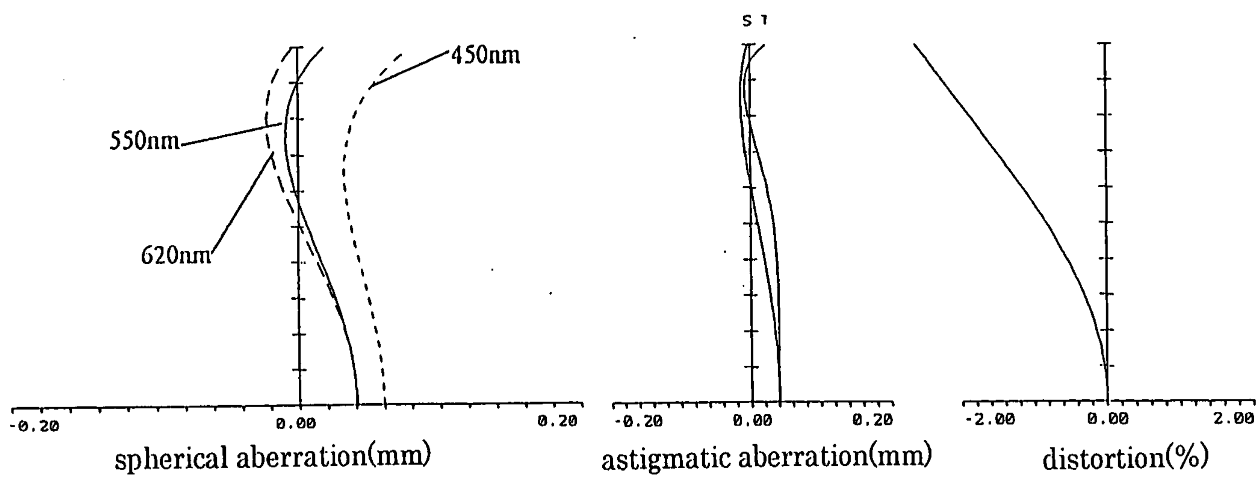


FIG. 2A


450nm
550nm
620nm
-0.20
0.00
0.20
spherical aberration(mm)
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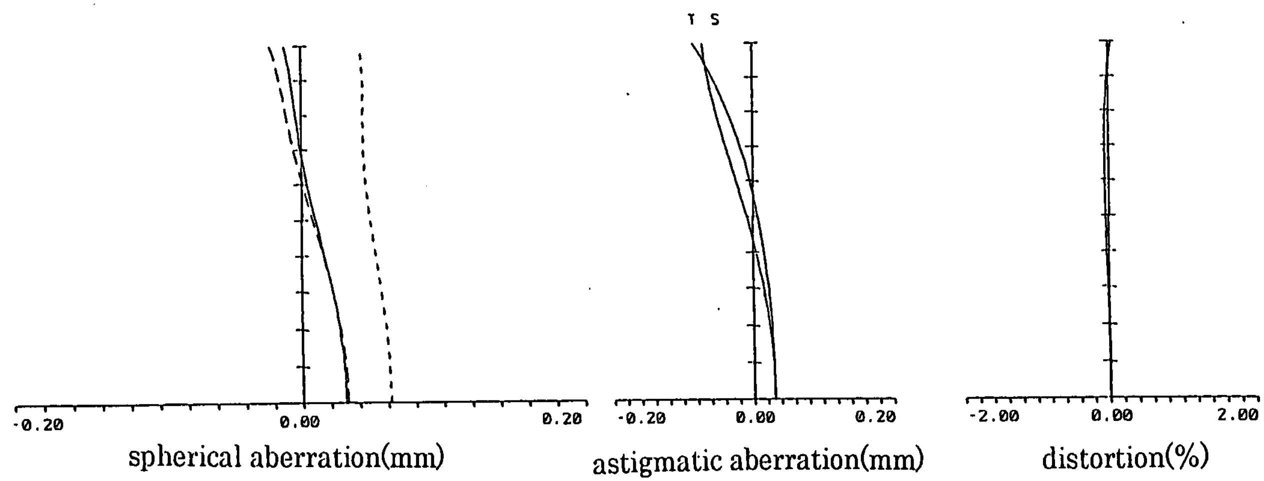
astigmatic aberration(mm)
-2.00
0.00
2.00
distortion(%)

F I G. 3 A


T S
-0.20
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spherical aberration(mm)
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astigmatic aberration(mm)
-2.00
0.00
2.00
distortion(%)

F I G. 4 A